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ABSTRACT

Presented and discussed is a model which can be used by educators who want to develop an interdisciplinary map skills program in geography and mathematics. The model assumes that most children in elementary schools perform cognitively at Piaget's concrete operational stage, that readiness for map skills can be assessed with Piagetian or Piagetian-like tasks, and that the Brunerian model for concept formation can be applied to mapping instruction. The model's seven skills which comprise the curricular scope for elementary mapping experiences are symbols, perspectives, direction, distance, location, scale, and relief. For each geographic map skill, the model lists its companion mathematics skill, a question which defines the skill's scope, and the related assessment task. For example, the companion mathematics skill to symbols is experience in recording data--first concretely, then pictorially, and finally with mathematical symbols. To define a symbol or a concrete recording the question "What Is It?" could be asked. The assessment task might consist of a picture-symbol substitution. The paper concludes with a description of an inservice teacher training workshop based on this model. (RM)

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A DEVELOPMENTAL MAPPING PROGRAM INTEGRATING GEOGRAPHY AND MATHEMATICS

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A DEVELOPMENTAL MAPPING PROGRAM

INTEGRATING GEOGRAPHY AND MATHEMATICS

Research over a forty-year period (e.g., Miller, 1931; Bettis & Manson, 1975) indicates that children in elementary schools are not proficient readers of maps. Two major reasons for that circumstance appear to be that 1) mapping curricula rarely reflect what is known about the manner in which cognitive spatial ability is developed in children and adolescents and 2) many educational practices inadvertently confuse children's understanding of the relationship between maps and the world around them.

Based on a review of literature spanning five decades (Muir, 1983) as well as informal research efforts by the authors, a model for a mapping curriculum was developed in 1981. Six assumptions underlay the model:

--Most children in elementary schools perform cognitively at Piaget's concrete operational stage.

--Six skills and one broad concept comprise the curricular scope for elementary mapping experiences.

--Foundation experiences with maps exist in both the social studies (geography) and mathematics curriculum.

Table 1

MODEL FOR A DEVELOPMENTALLY-BASED MAP PROGRAM

Map Skills			
Social Studies	Mathematics	Question	Assessment Task
Symbol	Concrete Recording	What is it?	Picture-symbol substitution*
Perspective	Euclidian Geometry	From which view?	Coordination of Perspectives
Direction	Movement & Direction	Which way?	Use of environmental, personal and global terms*
Distance	Measurement	How far?	Relative Distance Conservation of Length Spontaneous Measurement
Location	Coordinate Geometry	Where?	Natural Axes+
Scale	Horizontal Ratio	How large?	Ratio* Horizontality
Relief	Vertical Ratio	How high?	Verticality (Proportion).
. . . . .			
Territoriality	Area and Set Inclusion		Territorial Decentration

*These tasks were designed by the researchers; all others appear in published research

+Also referred to as "map conceptualization," "diagrammatic layouts," and "localization of topographical positions" task

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--Readiness for map skills can be assessed with Piagetian or Piagetian-like tasks.

--The Brunerian model for concept formation, i.e., enactive, iconic, symbolic, is appropriately applied to mapping instruction.

--Valid experiences in the six map skills can be developed for each grade level, kindergarten through sixth.

Each geographic map skill in the model (see Table 1) appears with its 1) companion mathematics skill, 2) a question which defines the skill's scope, and 3) the related assessment task. Similar information is provided for the concept of territoriality as well.

Map Skills

Symbols

While symbols are the easiest and most fully understood map skill, they can bewilder a child. Color distinguishes some symbols while shape is the major characteristic of others. Some symbols represent things which children have seen; others represent imaginary entities which no one has seen. In mathematics, experience in recording data--first concretely, then pictorially, and finally with mathematical symbols--is akin to the recommended sequence with map symbols. Systematic instruction in symbols progresses from experience with 1) real objects, 2) models, 3) detailed drawings, 4) simplified drawings, 5) child-generated symbols, and to 6) cartographic

symbols. No Piagetian task corresponds to this ability. However, the researchers developed and are validating an exercise in which very young children replicate a drawing, each time using increasingly abstract symbols.

Perspective

The ability to imagine or recognize an object from the "bird's eye" perspective is fundamental to map understanding since that is the perspective from which maps are drawn. Nevertheless, formal instruction in that skill is notably absent from most commercial map programs. In mathematics, the companion skill lies in the field of Euclidean geometry. Piaget's coordination of perspectives task (Piaget & Inhelder, 1956) finds that children progress through three stages as they develop this ability. First, they egocentrically imagine that their personal viewpoint represents all possible perspectives. Later, while they realize that other perspectives exist, they are unable to correctly describe them. Finally, they select or describe other points of view accurately.

Direction

Understanding of direction also develops cognitively in three stages. Initial directional concepts are environmental, commonly represented by prepositions, e.g., above, over, and behind. Awareness of personal directions follows, i.e., left, forward, front, and their antonyms. Clockwise and counterclockwise are also personal directions, but they relate less directly to maps and are acquired later, following formal

instruction in reading clock faces. Lastly, children develop an understanding of global directions, those which appear on a compass. Unfortunately, mapping programs tend to begin with global concepts; moreover, map exercises with global direction usually are confined to paper-and-pencil tasks rather than applied to the real environment. Experiences in exemplary mathematics programs (e.g., Developing Mathematical Processes, 1974) parallel the recommended sequence. Children's cognitive development in direction can be assessed with individual interviews which use sample terms from each category of direction.

Distance

Computation of distance is a measurement task closely related to mathematical skills involving both nonstandard and standard measures. Exercises which require the use of ratio, e.g., 1" = 100 miles, usually require more advanced experience with standard measures, ratio, and multiplication. Three Piagetian tasks assess readiness for measurement. Relative distance (Piaget, Inhelder & Szeminski, 1960) is conserved when the child realizes that the distance between two points is reversible. Length is conserved when one understands that two lines are of equal length even though they appear differently, e.g. straight versus zigzagged. Children demonstrate the ability to use spontaneous measures when, without prompting they use nonstandard tools to build constructs of equal height from materials of different size.

Location

Two systems are employed to locate places on maps: simple gridworks and longitude-latitude. While the former system can be comprehended by most elementary pupils, the use of longitude and latitude is more complex. The two systems can be contrasted by analogy to single- versus four-quadrant graphs. A simple gridwork, like a single-quadrant graph, consists of one general area using only positive coordinates. Longitude and latitude utilize global directions as well as numbers in much the same way that four-quadrant graphs contain both positive and negative coordinates. Mathematical experience in coordinate geometry parallels the skill of location. As an assessment tool, Piaget's natural axes task (Piaget & Inhelder, 1956), evaluates a child's ability to use more than one reference point simultaneously.

Scale

In mapping programs, scale is not to be confused with using a "scale-of-miles" to compute distance. Rather, scale refers to the size of a map's reproduction. Some authors believe that both ratio and proportion relate to the concept of scale. However, proportion explains the relationship among four entities (i.e., a is to b as c is to d) while ratio compares two units (i.e., a to b). Only two comparisons are made in scale: understanding of the relationship between 1) an area on a map and 2) its actual size in space. It also requires the ability to perceive that the area's size remains

constant when different scales are used on two or more maps. Because scale exists in the horizontal plane, Piaget's horizontality task (Piaget, Inhelder, & Szemenski, 1960) is an appropriate assessment exercise. It asks the child to predict the waterline in an imaginary bottle half-full of liquid. In addition, a researcher-developed task determines if the child uses ratio rather than additive or factoring processes when making comparisons.

Relief

Relief involves determining elevation by consulting a chart of intervals. Most relief exercises on maps utilize large scale rather than small scale maps. The latter denote contour by distinguishing steep or gradual slopes, usually with lines drawn close together or far apart. Unfortunately, instruction with small scale contour maps, logical precursors to understanding elevation in large scale, is absent from commonly used programs in the United States. Piaget's verticality task (Piaget, Inhelder & Szemenski, 1960) assesses understanding of the plane in which relief or contour exist. It determines if one can arrange a figure on a diagonal line with reference to the horizontal base rather than to its diagonal slope. Mathematical experiences related to relief, or ratio in a vertical plane, compare maps to the actual terrain or height which they represent. Authors sometimes refer to this skill as including proportion as well as ratio. However, an understanding of proportion is needed only for such relief

activities as those which estimate the height of a building by comparing the shadows cast by it and a shorter object. In that case, ability to understand proportion can be assessed by a task which evaluates prediction of the height of a second figure, when two figures have first been compared by a different measurement (Karplus & Peterson, 1970).

Other Map Skills

Even under optimal research conditions, some skills appear impossible to teach to students below grade seven. Others, while possible, require so much effort and ingenuity that they are best delayed until abstract mental ability emerges; then valuable instructional time can be used more efficiently. Skills which are not appropriate to the elementary grades include work with map projections, understanding of time zones, use of longitude and latitude, comparison of different map scales, and interpretation involving two or more maps.

Territoriality

The concept of territoriality applies less directly to the mapping curriculum. Territoriality requires understanding of concepts such as city, state, and nation. The concept of city is easily acquired by most elementary students since they have direct experience with that area. However, the concepts of state and nation are less easily understood. Research (e.g, Renner, 1951) suggests that adequate understanding of those areas, about which one learns vicariously, is rarely acquired

before ages 11 or 12. Nevertheless, maps of remote territories comprise most of those which appear in commercial materials. Piaget & Weil (1951) describe an interview to assess the ability to understand territorial relationships. Related mathematics skills require understanding both area and the relationships between sets and subsets.

In-service Training Worksnop

While efforts to produce a complete K-6 mapping curriculum based on this model continue, two groups of in-service elementary school teachers have participated in a staff development program. Each group attended a forty-hour training workshop designed to achieve eight major objectives:

1. Teachers attempted to draw instructional implications from Piaget's theory of cognitive development, with particular emphasis on spatial concepts.

2. Participants observed, recorded and shared results of assessment tasks administered individually to elementary-age children. Considerable time was devoted to sharing and discussing those observations with other teachers.

3. Teachers became aware of classroom practices which confound children's spatial abilities.

4. Emphasis was placed on instructional experiences for which students collect data and construct many types of maps: political, population, contour, elevation, temperature, and weather. This objective was based on Bartz's (1970) contention

that "the ability to make maps nearly guarantees the ability to read them."

5. Teachers classified instructional activities from existing social studies and mathematics materials or designed new activities for each step in Bruner's schema of concept representation (i.e., enactive, iconic, and symbolic.

6. Commercial mapping programs as well as map exercises in elementary social studies textbooks were evaluated in terms of their appropriateness to pupils' cognitive development.

7. Considerable time was devoted to improving the teachers' understanding of maps, since recent studies indicate that teachers suffer deficiencies in those skills (Arceneaux, 1978; Garvida, 1977; Giannangelo & Frazee, 1977). While the only variable which correlates significantly to teachers' map reading ability is the grade level at which they teach (Stjernberg, 1974), efforts in the workshop were based on the hope that in-service activity might be more effective than preservice training. Besides lectures, films, and demonstrations, learning centers provided hands-on experience. Twelve centers utilized activities from exemplary commercial map programs; ten others were developed by the workshop instructors. Finally, two centers required interaction with microcomputer software as well as with LOGO programming language (Papert, 1980).

8. The final element of the workshop dealt with testing. Besides analyzing item-objective correspondence on

standardized tests, participants studied three specialized evaluation instruments:

A Map Understanding Exercise (Feldman & Salomon, 1973) is a 22-item multiple choice test. Each item option corresponds with a Piagetian level to diagnose cognitive development as well as map reading ability.

The Piagetian Logical Operations Test (Staver, n.d.) assesses the degree of abstract spatial development at the formal operational stage.

The Spatial Visualization Test (Lappan & Winter, 1981) evaluates the ability to imagine three-dimensional block structures from various perspectives.

Additional large group experiences included use of a "Flight" simulation (Reese, 1976), indoor and outdoor orienteering, measuring and enclosing a space equal to one acre, and working with aerial photographs taken from airplanes as well as from satellites.

The workshop directors have not attempted to evaluate instructional change. But preliminary data, not yet formally analyzed, suggest that considerable gains were achieved especially in making instructional applications of Piagetian and Brunerian theory.

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